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 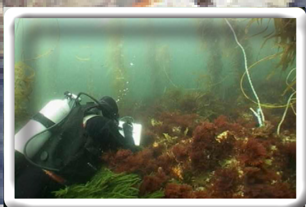 

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Contents


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Int. J. Aqua. sci. & Tech. Vol. 3 (1) 2015, pp.1-5

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DIVERSITY OF DRAGONFLIES AND DAMSELFLIES IN DIFFERENT AREAS OF JABALPUR (M.P.)

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ABSTRACT

Òdonata is Considered as environment indicator group of freshwater habitats. Thus there is a need to have a good baseline data to use it for monitoring fluvial habitats. The dragonflies and damselflies are major insect group associated with water courses. Odonata assemblages with reference to their habitat characters have not been widely studied in Jabalpur. The objectives of the present study were to explore the diversity of dragonflies and damselflies (**class**- Insecta, **phylum**- Arthropoda) in different areas of Jabalpur (M.P.) Total species of dragonflies and damselflies belonging to 5 sub-families were recorded during the course of study.

Key Words : Dragonflies, Damselflies, Bhanwartal Garden, ZSI.

PAGES: 5 REFERENCES: 8

INTRODUCTION

Insect survey facilitate characterization of the land/water interface, structural heterogeneity and hydrological features of aquatic system. Among the essential tools in ecological assessments in the land water interface characterization of the odonates communities (Dragonflies and Damselflies) has been a widely accepted tool. Odonata were the first insect group that has been globally assessed. Dragonflies and Damselflies are a flagship group and an important component of aquatic ecosystem in which they can often be to predators. Their sensitivity to environmental conditions makes odonates excellent biological indi-

[2] *Corresponding author* **P.B.Meshram**

cators of environmental conditions (Brown 1991; Samways, *et. al.*, 2010).

The dragonflies and damselflies are amphibiotic insect. They spend a major part of their life cycle in fresh water ecosystem. The adults are generally predacious insects, while the larvae are carnivorus and voracious. Even though the species are usually highly specific to a habitat. Some have adapted to urbanization and use man made water bodies. Being primarily aquatic. Their life cycle history is closely linked to specific aquatic habitats (Andrew *et. al.*, 2009).

Dragonflies and Damselflies occur in the vicinity of different freshwater habitats like-rivers, streams, marshes, lakes and even small pools and rice fields. Odonates are good indicators of eeviromental changes as atomospheric temperature and the weather conditions. Many species of Odonates inhabiting agro ecosystem play a crucial role controlling pest population (Tiple *et. al.,* 2008).

MATERIALS AND METHODS

The Odonates were collected near the Z.S.I. Campus, Jabalpur (M.P.), Govt M.H. College of H.Sc. & Science Jabalpur, Bhanwartal garden and Nehru park. They were collected by using net- sweep and hand picking methods from various habitats. Collected Odonates were sorted out, pinned and identified with the help of reference collection and literature present in Z.S.I. and fauna of British India. Some photographic documents were also done.

RESULT AND DISCUSSION

A total of 10 species of Odonates belonging to five sub-families, Libellulinae, Sympetrinae, Coenagrionidae, Trithemistinae, Trameinae of family Libellulidae.

Systematic account :

Phylum - Arthropoda
Class - Insecta
Order - Odonata
Sub-order- Anisoptera
Family -Libellulidae

Sub-family – Libellulinae

Genus – Orthetrum Newman

OrthetrumPruinosumneglectum(Rambur) Orthetrum Sabina (Drury)

Nodal index

11-14	15-10	9-15	15-10
12-11	10-12	11-10	11-10

Distribution- Bhanwartal garden, Z.S.I., Nehru park.

Sub-family - Sympetriemis

Genus - BrachythemisBrauer

Brachythemis Contaniminata (Fabr.)

Genus – Bradinopyga Kirby

Bradinopyga geminate (Rambur)

Genus – CrocothemisBrauer

CrocothemisServillaServilla(Drury)

ISSN: 2320-6772

Genus – Diplacodes Kirby

DiplacodesTrivalis(Rambur)

Nodal index $\begin{array}{c|c} 10\text{-}14 & 14\text{-}10 \\ \hline 12\text{-}11 & 11\text{-}11 \end{array} \quad \begin{array}{c|c} 12\text{-}15 & 14\text{-}14 \\ \hline 15\text{-}12 & 10\text{-}12 \end{array}$

Distributionn – Z.S.I. And Nehru park.

Sub-family – Trithemistinae

Genus – TrithemisBraller

Trithemis aurora (Burmeister)

Nodal index $\begin{array}{c|c} 7\text{-}7^{\frac{1}{2}} & 7^{\frac{1}{2}}\text{-}7 \\ \hline 6\text{-}6 & 6\text{-}6 \end{array} \quad \begin{array}{c|c} 6\text{-}8^{\frac{1}{2}} & 7^{\frac{1}{2}}\text{-}6 \\ \hline 6\text{-}6 & 6\text{-}6 \end{array}$

Distribution- Govt. M.H. College Jabalpur & Z.S.I..

Sub-family – Trameinae

Genus – Pantalahagen

Pantalaflavescens (Fabr.)

Genus – Trameahagen

Trameabasilarisburmeisteri (Kirby)

Nodal index $\begin{array}{c|c} 7\text{-}12^{\frac{1}{2}} & 13^{\frac{1}{2}}\text{-}8 \\ \hline 9\text{-}7 & 7\text{-}9 \end{array}$

Distribution- Nehru park&Bhanwartal garden.

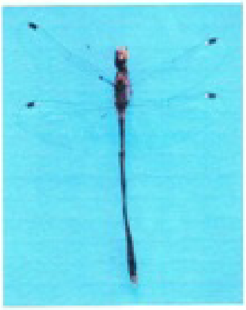
Sub-family – Coenagrionidae

ISSN: 2320-6772

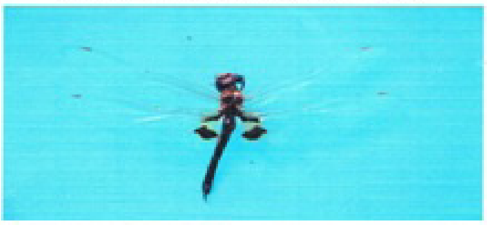
Brachythemis contaminata (Fabr.)

Crocothemis servilia servilia (Drury)

Bradinopyga geminata (Rambur)



Tramea basilaris burmeisteri Kirby



Trithemis festiva (Rambur)

Trithemis aurora (Burmeister)

Pantala flavescens (Fabr.)

Diplacodes trivialis (Rambur)

Orthetrum sabina sabina (Drury)

Orthetrum pruinosum neglectum (Rambur)

Field Photo

Genus – Agriocnemis

Agriocnemisfemina

Distribution- Z.S.I.

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Int. J. Aqua. sci. & Tech. Vol. 3 (1) 2015, pp. 6-16

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IMPACT OF FLUORIDE ON TEETH AND INTELLIGENCE OF TRIBAL CHILDREN IN BARKAGAON, HAZARIBAGH, JHARKHAND, INDIA

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ABSTRACT

Water is of paramount importance for the existence, development and sustenance of life. Water at any place also plays a vital role in health, wealth and prosperity of people living there. Over millions of people in the world have no access to safe drinking water. Groundwater is one of the major sources of drinking water but geogenic contaminants including fluoride have affected groundwater in more than 200 districts of 20 states of India. Fluoride is one of the most important elements for calcification of bones and teeth where as excess intake (›1.5 mg/lit.) may affect skeletal, non skeletal and dental fluorosis which has direct bearing on Intelligence Quotient (I.Q.).

Fluoride content in the collected water samples from five tribal dominated pockets of Barkagaon, Hazaribag, and Jharkhand, India showed that the water samples contain fluoride above the permissible limit in all the seasons (July 2011 - June 2013). The highest average concentration of fluoride was recorded in Potanga basti (3.86 +/- 0.8 mg/lit.) and lowest in Garsulla basti (1.99 +/- 0.8 mg/lit.). Dental and mental health (Intelligence Quotient) of 567 school children (06-14 yrs.) were respectively evaluated by Dean's Index and Raven's coloured progressive matrices which indicated that almost 87% children were suffering from dental fluorosis where as 73% were having extremely low to low average I.Q. .

It is thus clear that the dental fluorosis and I.Q. among children have direct relationship on fluoride concentration in drinking water. Probably the higher fluoride concentration in the study pockets is due to geogenic contamination and injudicious exploitation of nature. Conclusion: The affected children in endemic area of fluorosis are at risk for impaired development of intelligence.

KeyWords: Drinking Water, Fluoride, Dental Health, Tribal, Intelligence Quotient, Barkagaon.

PAGES: 11 REFERENCES: 15

INTRODUCTION

Water is basic need and one of the most essential natural resources for all living systems on our planet earth. About 97 % is sea water and 2 % is frozen in glaciers & polar ice caps remain 1 % of the world's

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water is useable to us. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population, accelerated pace of industrialization and modernization. The pressure on water demand has increased manifolds which are fulfilled by ground and surface waters. Water acts universal solvent which dissolves the minerals of rocks during percolation and ultimately changes the quality of ground water. In addition, various anthropogenic activities pollute and degrade the drinking water resource. The suitable quality of drinking water is still a dream for most of the human population.

No doubt, two third of human body constitutes water, without which, we would die within a few days. An average intake of water by an individual is 13.1 % of the body weight (Kumar and Sadhu, 2013). A mere 2 % in drop of water level of the body may trigger the symptoms of dehydration. More over 80 % diseases of mankind are water borne (WHO, 1996). Both surface and ground water are contaminated by different ways. The ground water resources have been rendered unsafe due to various reasons (Khayum *et. al.*, 2011). Geogenic contaminants including fluoride have affected ground water in more than 200 districts of 20 states of India (Gopal pathak, 2014).The source of occurrence of fluoride in groundwater is mainly of geogenic. Geogenic contamination of groundwater depends mainly on geological setting of the area. The fluorides content of groundwater can originate from the dissolution of fluoride bearing minerals in the bed rocks and therefore, bed rock mineralogy is in general a prime factor for the variation in fluoride content of groundwater (Rasheed, *et. al.*, 2012). Fluoride is one of the most essential elements for human health, playing vital role in the calcification of bones and teeth. Above the permissible limit i.e. 1.5 mg/ litre (BIS, 2003 & WHO, 1996), it causes severe health problems including dental fluorosis (Kumar and Sadhu, 2013) as well as intelligence quotient, (Saxena Sudhanshu *et. al.*, 2012). Ghosh *et. al.*, 2013 has elaborated the various impacts on the entire human system (fig.). The skeletal fluorosis causes pain in different parts of the body (WHO, 1996) where as non skeletal fluorosis may cause different ailments (Ozha and Mathur, 2001) and the dental fluorosis manifests variety of problems in the teeth (Murkute and Bandhan, 2011) as well as affect the Intelligence Quotient (Saxena *et. al.*, 2012). In Jharkhand, very little study has been done on the occurrence of dental fluorosis and on I.Q. of children due to fluoride in tribal dominated areas. In view of the above, the present investigation has been carried out to evaluate the extent of dental fluorosis and its impact on intellectual function among tribal children (06-14yrs) in some of the tribal dominated pockets of Barkagaon block, Hazaribagh, Jharkhand, India.

The Study Area

Barkagaon one of the important block of Hazaribagh District of Jharkhand State, India being situated 23^0 52′ 5″ N latitude and 85^0 14′ 15″ E longitude and altitude of 600 meters from mean sea level (Fig). It is 25 KM west from District head quarters Hazaribagh and 67 KM from State capital Ranchi towards South. The Barkagaon Block is bounded by Keredari Block towards west, Hazaribagh Block towards North, Sadar Block towards East, and Patratu Block towards South. The district headquarter is about 65 km away from study area and is connected by SH- 07 to NH- 33. Barkagaon consists of 173 Villag-

es and 23 Panchayats. Hazaribagh district population constituted 5.26% of total Jharkhand population as per census report 2011. Census report '2001' indicated that more than 80% tribal population resides in Potanga and Garsulla panchyats under Barkagaon block. This block reported to be one of the largest coal deposit area of Asia. Legal and illegal mining activities are creating geogenic contamination due to over exploitation. This area is rich in biodiversity and is also surrounded by moderate to dense forest traversed by many natural streams. Topography of the area is undulating. An average rain fall of 1485 mm/year. Five sampling pockets namely Potangabasti, Jojotola, Murgatola, Garsullabasti and Bihadbasti have been selected for the study.

MATERIAL AND METHOD

Portable water samples from each pocket of the study area were collected at the interval of 3 days from hand pumps in sampling bottles of 1 litre capacity during rainy, winter and summer seasons from July 2011 to June 2013. APHA, 2005 protocol was adopted for fluoride analysis. The fluoride level in samples was evaluated in mg/L within 24 hours of collection in the field laboratory. An ion specific F electrode (Orion 290+) was used in the field laboratory with TISAB-II solution in 1:1 volume ratio with the samples. Fluoride level in the study area was determined and compared with the standard one prescribed by BIS (10500-1991). The relationship between fluoride concentration in drinking water and its effect were assessed with reference to report of Kausik *et. al.*, 2012 (**Table-1**). The characteristic of teeth among school children (06-14 yrs) was also assessed by Dean's Index (Dean, 1934) and intelligence testing was done by the Raven's Colored Progressive Matrices (RCPM, 1992). The RCPM is a non verbal multiple choice I.Q. tests designed for 06- 14 yrs old children. The models were presented in the form of matrices. In each test item, the child was asked to identify the missing part to complete the model. The average time taken to complete the test was 30 minutes. The test comprised of 30 problems, beginning with easy problems and ending with difficult ones. Each question contained a matrix of geometric design with six alternatives for one removed cell. Only one of the options fitted correctly. The obtained data were formulated and statistically analyzed.

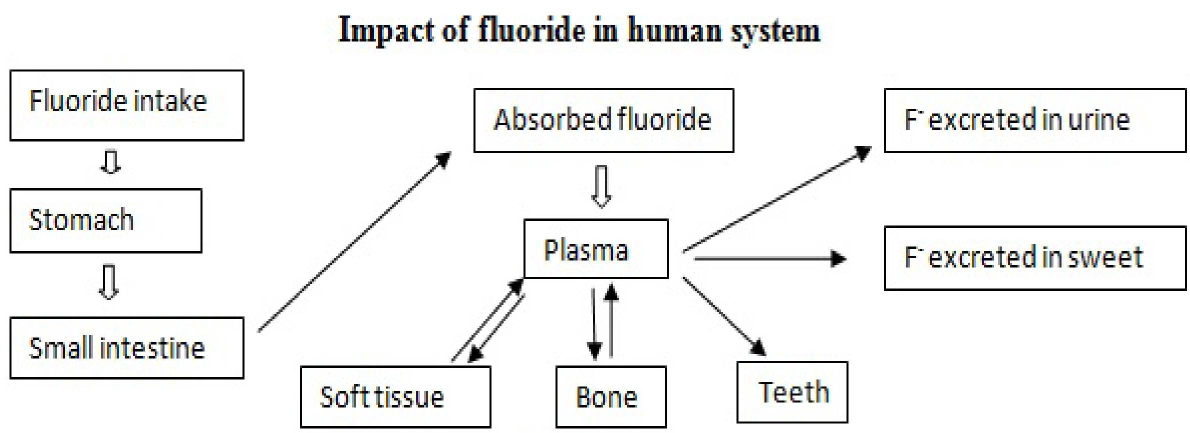

Fig-1

RESULT AND DISCUSSION

Drinking water samples collected from the study pockets were analyzed to estimate the fluoride concentration as per standard protocol given by APHA. **Table-1** shows calculated mean ± S.E. of data obtained. It is observed that all the samples collected in rainy, winter and summer seasons showed higher concentrations of fluoride than permissible limit - 1.5 mg/lit (WHO, 1996). The highest average concentration of fluoride throughout the year was recorded in Potanga basti where as it was lowest in Garsulla basti. The relative average concentrations of five pockets were recorded in the ordered as Potanga basti> Murgatola> Jojotola> Bihad basti> Garsulla basti. The higher fluoride concentration in the study Pockets ranges from 1.98± 0.5mg/lit to 4.90± mg/lit. Which is due to geogenic contamination and excess mineral exploitation (Kumar and Sadhu, 2013)?

Parallely, the impact of fluoride among school children (06-14 yrs) of the study pockets has also been diagnosed by Dean's Index for severity of dental fluorosis which shows several degree of dental fluorosis (fig-2). The observation of teeth among 567 school children on the basis of Dean's Index reveals that almost 77% children were suffering from dental fluorosis where as the percentage occurrence of different categories of fluoride affected teeth in the study pockets were 22.78% - Normal, 15.02%- Questionable, 12.91%- Very mild, 23.70% - Mild, 16.44% - Moderate and 9.15%- Severe and shown (table-3). All these observations and results presented in the table II & III and figs. 2 & 3 seem to indicate that the dental fluorosis among children is directly related to fluoride concentration in drinking water. Similar conclusion has also been given by Ruan *et. al.*, 2004, Kumar & Verma, 2007, Kumar & Sadhu, 2013, Gopal pathak, 2014 in this regard. Further study was conducted to evaluate the relationship between dental fluorosis and **Intelligence Quotient (I.Q.).** The mean IQ score of children inrelation dental fluorosis was found significantly higher than those children who had no dental fluorosis. The mean I.Q. scores did not vary with the severity of dental fluorosis as classified by Dean's Index rather variation is random. The children's I.Q. score were converted to percentile as per Raven's Colour Matrices. The impact of fluoride on I.Q. has been reported by researchers Tang *et. al.*, 2008, Nagarajappa *et. al.*, 2013. The average I.Q. of children living in the area with high fluoride content in the potable water was significantly lower than standard I.Q. of children taking potable water contain Fluoride (Susheela *et. al.*, 2005 and Nagarajappa *et. al.*, 2013). The present study also showed same result, it was noticed that the percentage of children with dental fluorosis was more in extremely lowered group and almost 73% children were below average to extremely low I.Q. (**Table-4**).

CONCLUSION

Water is life but unfortunately, quality drinking water is not sufficiently available in the study area. Most of the sources of drinking water are unsafe to use without some sort of treatment including defluoridation. Otherwise people inhabiting there will face a lot of health hazards. Therefore, as precautionary and preventive measures, naturally occurring Bethonite candle may be used in removing extra fluoride in drinking water (Gupta *et. al.*, 2014). Beside, a unit of oral health and hygiene should be established in the area for proper assessment, guideline

and monitoring of drinking water quality with the help of State and Central Govt., Health Department etc. Since the area is tribal dominated, special care should be taken at priority basis by the concerned authorities as well as NGOs for the maintenance of their health and proper survival.

Table 1: Effect of fluoride concentration

Sl. No.	Fluoride concentration in mg/L	Effect
01.	Less than 1.5	No effect
02.	1.5 to 3.0	Dental Fluorosis (discoloration, mottling and pitting of teeth)
03.	3.0 to 6.0	Mild skeletal fluorosis
04.	More than 6	Crippling skeletal fluorosis

Table-2: Showing the seasonal variation of fluoride content in ground water

Season	Month	V I L L A G E S				
		*Mean+S.E. in mg.	*Mean+S.E. in mg.	*Mean+S.E. in mg.	*Mean+S.E. in mg.	*Mean+S.E. in mg.
		Garsullabasti	Jojotola	Murgatola	Potangabasti	Bihadbasti
Rainy	July11 & 12	2.14±0.7	2.25±0.8	2.45±0.7	2.50±0.7	2.17±0.7
	Aug 11&12	1.80±0.7	1.90±0.6	1.75±0.8	1.95±0.8	1.65±0.8
	Sept 11&12	1.84±0.6	1.75±0.7	1.92 ±0.6	2.20±0.7	1.95±0.5
	Oct 11 & 12	2.17±0.6	1.93±0.6	2.66 ±0.6	2.10±0.7	2.25±0.7
	AV:Values	**1.99±0.8**	**1.95±0.7**	**2.19±0.6**	**2.18±0.7**	**1.98±0.7**
Winter	Nov 11&12	2.20±0.7	2.80±0.8	2.30±0.7	2.90±0.8	2.42±0.7
	Dec 11&12	1.98±0.7	2.90±0.8	2.76±0.8	3.50±0.8	2.65±0.7
	Jan 12&13	2.20±0.7	3.16±0.9	2.95±0.8	3.90±0.9	2.90±0.8
	Feb 12&13	2.42±0.7	3.30±0.9	3.51±0.9	3.39±0.9	3.35±0.9
	AV:Values	**2.20±0.7**	**3.04±0.9**	**2.88±0.8**	**3.42±0.9**	**2.57±0.7**
Summer	March12&13	2.55±0.7	3.40±0.9	3.42±0.8	3.60±0.9	3.54±0.8
	April 12&13	2.94±0.8	3.65±0.9	3.70±0.8	3.85±0.9	3.75±0.8
	May 12&13	3.02±0.7	3.35±0.8	2.75±0.7	3.25±0.7	3.30±0.7
	June 12&13	3.40±0.7	4.90±0.9	4.53±0.9	4.75±0.7	3.92± 0.7
	AV:Values	**2.98±0.7**	**3.82±0.9**	**3.85±0.9**	**3.86±0.8**	**3.60±0.8**

* 10 samples

Table-3: Showing the percentage occurrence of fluoride - affected teeth of children as per Dean's Index

Sl. No.	Villages	Number of cases (06-14 yrs)	Dean's Index					
			Normal	Questionable	Very mild	Mild	Moderate	Severe
01.	Garsullabasti	145	15.67%	18.36%	17.42%	22.15%	14.46%	11.94%
02.	Jojotola	84	25.82%	20%	17.94%	14.90%	14.64%	7.40%
03.	Murgatola	88	28.42%	24.58%	18.78%	9.22%	12.84%	6.16%
04.	Potangabasti	155	18.78%	20.52%	23.48%	18.64%	10.39%	8.19%
05.	Bihadbasti	95	24.64%	25.68%	18.08%	14.28%	12.19%	5.13%
Total Percentage of F– affected teeth			12.91%	15.02%	22.87%	21.83%	18.80%	15.83%

Table-4: Showing the percentage occurrence of Intelligence Quotient of children as per Raven's Index

Sl. No.	Villages	Number of cases (06-14 yrs)	Raven's Index					
			Extremely Low I.Q.<70	Border Line I.Q. 70-79	Low Average I.Q. 80-89	Average I.Q.90-109	High average I.Q.110-119	Superior I.Q.>120
01.	Garsullabasti	145	22.52%	25.42%	21.67%	16.30%	7.83%	5.26%
02.	Jojotola	84	26.64%	24.90%	22.58%	15.32%	6.43%	4.13%
03.	Murgatola	88	28.22%	25.55%	19.69%	15.76%	5.92%	4.86%
04.	Potangabasti	155	29.79%	26.58%	19.68%	15.46%	4.86%	3.63%
05.	Bihadbasti	95	23.88%	25.81%	20.64%	18.78%	6.80%	4.09%
Total Percentage of I.Q.			26.21	25.65	20.85	16.32	6.36	4.39

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Fig-1: Showing the location of the Study Area
(23^0 52′ 5″ N latitude and 85^0 14′ 15″ E longitude)
(Not to scale)

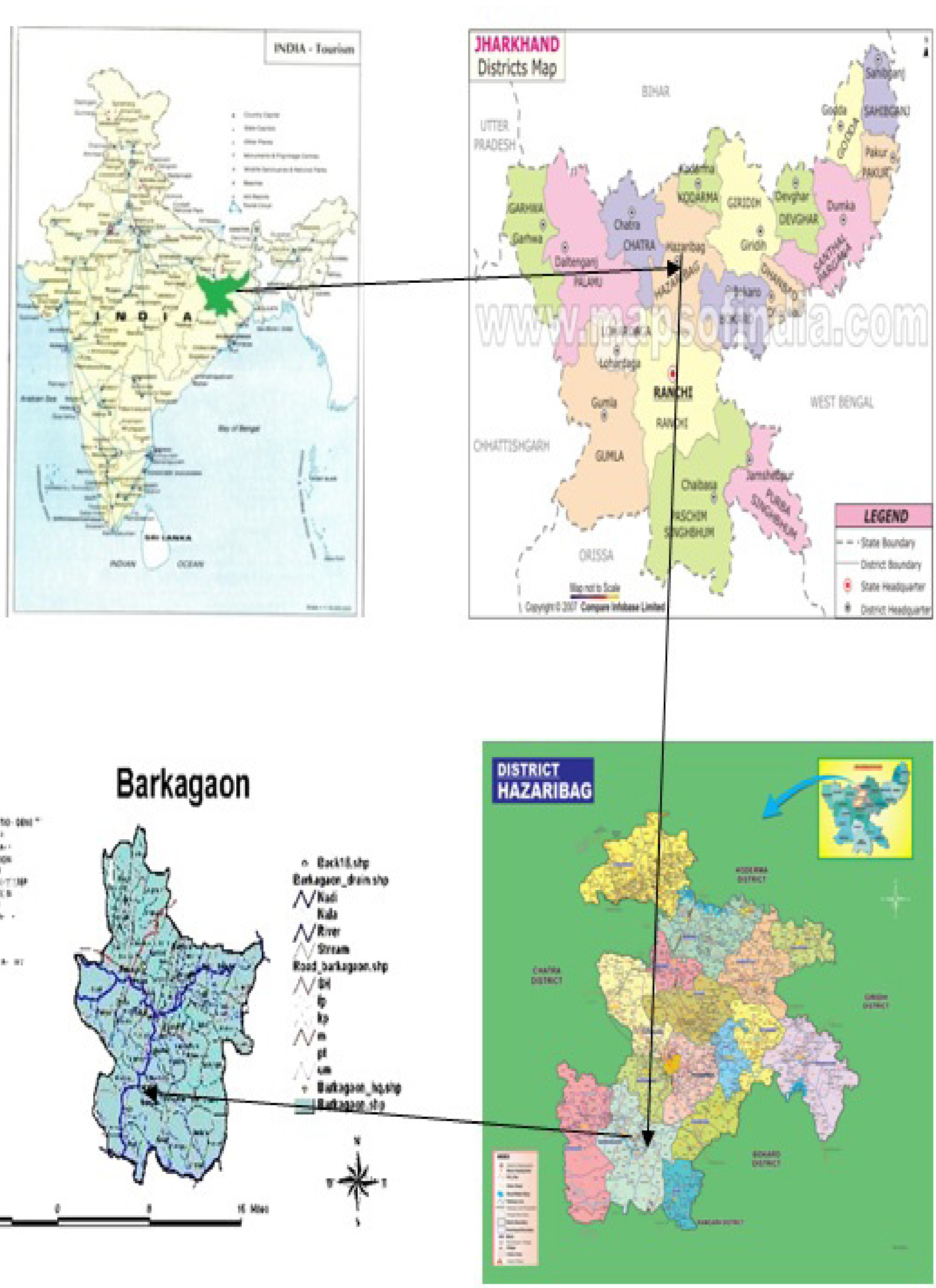

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Fig. 2: Showing the comparison of teeth of children of the study area with Dean's Index to identify the degree of fluorosis

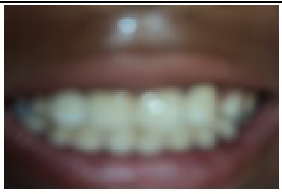
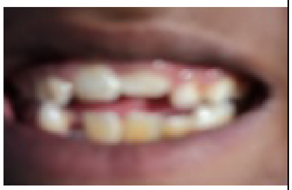
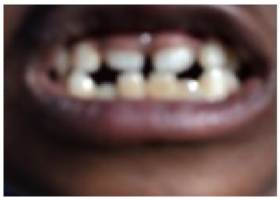
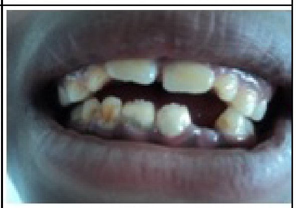
Sl. No.	Category of Dean's Index	Characters	Dean's Index Teeth	Observation of the teeth
01	Normal	Enamel is smooth and uniform in color		
02	Questionable	Enamel may exhibit some white flecks or small white spots. These are cases where there is not definitive fluorosis, but teeth do not qualify as "normal" either.		
03	Very mild	Less than 25% of the tooth surfaces display irregular white areas. Often these include cases where there are 1-2 mm of the tooth surface just at the cusp tips are affected.		
04	Mild	More than 25% of the tooth surface but less than 50% is affected.		
05	Moderate	Generalized areas of hypo calcification on all surfaces of the tooth, may exhibit attrition on susceptible tooth surfaces and brown spots may be present.		
06	Severe	Generalized pitting of the enamel on all surfaces, generalized brown discolorations, tooth shape may be affected as well.		

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Fig. 3: Showing the degree of fluorosis on children's teeth in Column

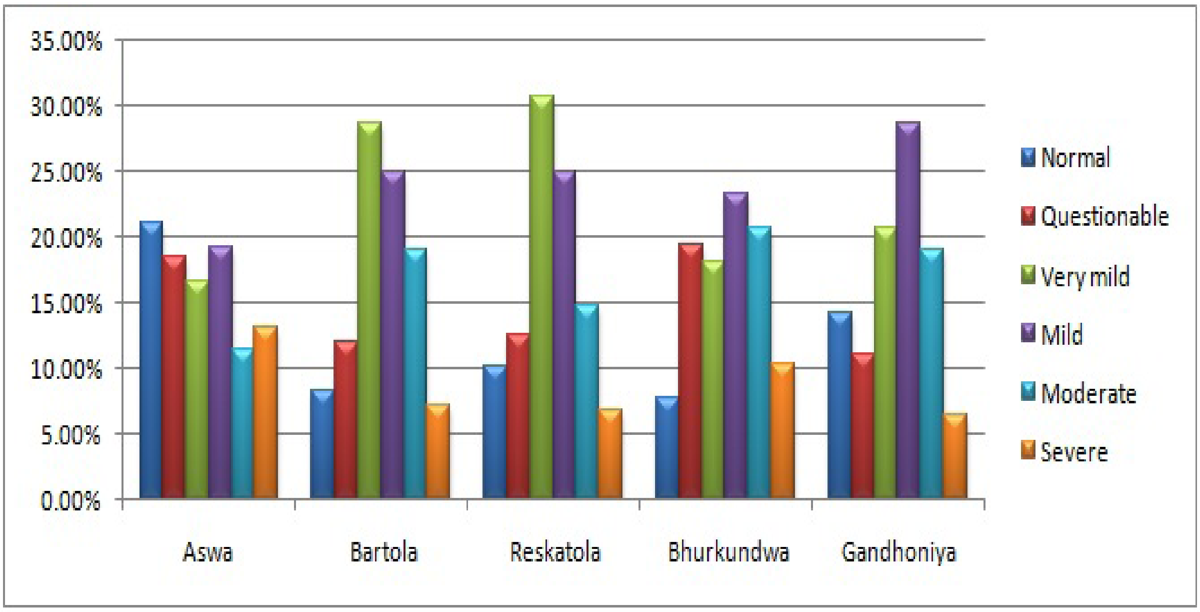
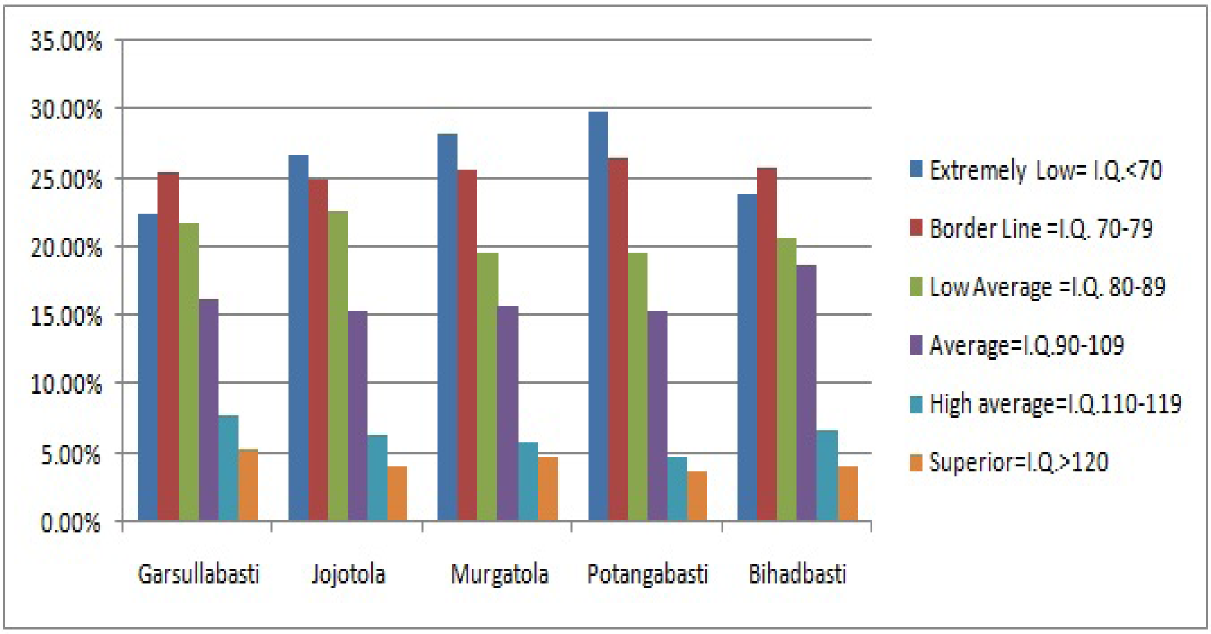


Fig. 3: Showing the degree of Intelligence Quotient of children as per Raven's Index in Column



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ASSESSMENT OF WATER USE EFFICIENCY AND WATER REQUIREMENT OF WHEAT USING CROPWAT MODEL

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ABSTRACT

Á field experiment was carried out at Agronomy Farm, Anand Agricultural University, Anand during *rabi* season in 2011-2012. The treatment comprised of five levels of irrigation schedule *Viz*., I_1 (CRI, TL, BT, FL, ML, SD), I_2 (0.4 IW: CPE ratio), I_3 (0.6 IW: CPE ratio), I_4 (0.8 IW: CPE ratio) and I5 (1.0 IW: CPE ratio) in randomized block design with in four replications. The highest WUE (18.0 kg ha^{-1} mm^{-1}) was recorded under I_2 (0.4 IW: CPE ratio) treatment and lowest (12.51 kg ha^{-1} mm^{-1}) under I1 treatment and the highest IWUE (2.23 kg ha^{-1} mm^{-1}) was recorded under I1 (CRI, TL, BT, FL, ML, DS) treatment and lowest IWUE under I_2 (0.4 IW: CPE ratio) treatment. Total crop water requirement simulated by model was 255.7 mm/dec during whole growing season of wheat. In initial stage minimum water requirement and ETc (28.8 mm/dec) was simulated by model. The highest crop water requirement (104.8 mm/dec) in mid stage of growth and decreased in late stage of wheat.

Key words: Wheat, CROPWAT Model, Water Use Efficiency, Water Requirement.

PAGES: 5 REFERENCES: 5

INTRODUCTION

Wheat (*Triticumaestivum L.*) is one of the most important cereal crops in large number of countries in the world. It provides about 20 % of total food calories for the human race. It is widely grown through the temperate zone and in some tropical and sub-tropical areas at higher elevation. Dwindling water resources and increasing food requirements require greater efficiency in water use, both in rainfed and in irrigated agriculture. Regulated deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on yield. Models can play a useful role in developing practical recommendations for optimizing crop production under conditions of scarce water supply. To assess the applicability of the FAO CROPWAT model for deficit irrigation scheduling, a study utilized data provided in studies from a joint FAO/IAEA coordinated research project (CRP) on **"The**

use of nuclear and related techniques in assessment of irrigation schedules of field crops to increase effective use of water in irrigation projects," carried out in Turkey, Morocco and Pakistan on cotton, sugar beet, and potato, respectively. The study revealed that the CROPWAT model can adequately predict the effects of water stress, but requires calibration of the main crop parameters. Procedures were developed to calibrate the various crop parameters based on research findings from the treatments. The study demonstrated that the model could be useful in improving the design of experimental methods in research studies and in identifying inconsistencies in procedures and results. Furthermore, the model permitted a more systematic analysis of results, a more uniform presentation of data, and a greater compatibility of results. Moreover, (FAO, 1992), this paper concludes that models are a powerful tool for that is useful predictions on deficit irrigation scheduling are possible under various conditions of water supply, soil and of crop management.

Scarce water resources and growing competition for water will reduce its availability for irrigation. At the same time, the need to meet the growing demand for food will require increased crop production from less water. Achieving greater efficiency of water use will be a primary challenge for the near future and will include the employment of techniques and practices that deliver a more accurate supply of water to crops. In this context, deficit irrigation can play an important role in increasing water use efficiency (WUE). Extensive field research is required to better understand the physical and biological processes that control crop responses to moisture stress.

MATERIALS AND METHOD

A field experiment was carried out at Agronomy Farm, Anand Agricultural University, Anand during *rabi* season in 2011-2012. India situated at 22° 35' N latitude and 72° 55'E longitude and at an altitude of 45.1 m above mean sea level. With a view to study the"**Assessment of water requirement and water use efficiency of wheat using CROPWAT model**".The treatment comprised of five levels of irrigation schedule *Viz*., I_1 (CRI, TL, BT, FL, ML, SD), I_2 (0.4 IW: CPE ratio), I_3 (0.6 IW: CPE ratio), I_4 (0.8 IW: CPE ratio) and I_5 (1.0 IW: CPE ratio) in randomized block design with in four replications.

Water use efficiency (Kg ha^{-1} mm)

The response of seed yield per unit of irrigation water used at varying level of irrigation was worked out by dividing per hectare seed yield of wheat crop obtained under various treatment with the total water use (mm) of the respective treatment and it was recorded as crop water use efficiency (kg ha^{-1} mm) which was worked out by the following formula which was described by Michael (1978).

$$\text{WUE (Kg ha}^{-1}\text{ mm)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Water requirement (mm)}}$$

$$\text{IWUE (Kg ha}^{-1}\text{ mm)} = \frac{\text{Yield} - \text{Yield rainfed}}{\text{IRGA}}$$

where :

Yield: Irrigation yield
Yield rainfed: Yield obtained from rainfed treatment

IRGA: Season amount of irrigation used There are two new versions of the CROPWAT: one is CROPWAT v 7.0 that contains a completely version in Pascal, developed with the assistance of the Agricultural College of Velp, Netherlands. It overcomes many of the shortcomings of the original 5.7 version. CROPWAT 7.0 is a DOS-application, but it runs without any problem in all MS-WINDOWS environments. Another one is CROPWAT for Windows that is written in Visual Basic and operates in the Windows environment. It has been developed with the assistance of the International Irrigation & Development Institute (IIDS) of the University of Southampton, UK.

Both versions use the same FAO (1992) Penman-Montieth method for calculating the reference crop evapotranspiration. These estimates were used in crop water requirements and irrigation scheduling calculations. Some of the interpolation methods used in CROPWAT for Windows is slightly different (up to 2%) to those used in CROPWAT 7.0.

RESULT AND DISCUSSION

Water and Irrigation Water use Efficiency

Water use efficiency and irrigation water efficiency was significantly influenced by different irrigation schedules which was showed in **Table 1**. The highest water use efficiency (18.00 Kg ha^{-1} mm^{-1}) was recorded under treatment I_2 (0.4 IW: CPE ratio) followed by treatment I_3.The lowest water use efficiency was recorded along with I_4 (0.8 IW: CPE ratio) treatment. The increase in water use efficiency under I_2 treatment might be due efficiency utilization of water under deficit irrigation which helped in obtaining higher productivity. Similar finding was also observed by Singh and Uttam, 1993 and Mahmood *et. al.*, 2002.

The highest irrigation water use efficiency (2.23 Kg ha^{-1} mm^{-1}) was recorded under treatment I_1 (CRI, TL, BT, FL, ML, DS) followed by treatment of I_3 and lowest irrigation water use efficiency was recorded also treatment of I_2 followed by I_4. The lowest irrigation water use efficiency (0.0 Kg ha^{-1} mm^{-1}) was recorded under treatment I_2 (0.4 IW: CPE ratio).The increase in irrigation water use efficiency due to the number and amount of irrigation water application. Similar results were obtained by Zhang *et. al.*, 1999.

Wheat Crop Water Requirement Simulation Using CROPWAT Model

The wheat crop water requirement (Table 2) simulated by CROPWAT model was 255.7 mm / dec. during the whole growing season. The wheat growing season was divided in four growth stages i.e. Initial stage, developmental stage, mid stage and late stage. The effective rainfall during whole crop growing season was nil. In initial stage of wheat crop growth, it needs minimum water requirement (28.8 mm / dec) in the November month and ETc was (28.8 mm / dec.). The crop water requirement increased by increasing the growth stage of wheat crop. The highest crop water requirement (104.8 mm / dec.) in the mid stage of growth and it decreased in late stage of wheat crop.

Table 1: Total water use efficiency (WUE) and irrigation water use efficiency (IWUE) values of the wheat under different irrigation regimes.

Irrigation Treatment	Yield (Kg $ha^{-1} mm^{-1}$)	Irrigation Water (mm)	WUE (Kg $ha^{-1} mm^{-1}$)	IWUE (Kgha^{-1} mm^{-1})
I_1- (CRI, TL, BT, FL, ML, DS)	4380.0	350	12.51	2.23
I_2-(0.4 IW:CPE)	3600.0	200	18.00	0.00
I_3 (0.6 IW: CPE)	4087.5	250	16.35	1.95
I_4 (0.8 IW: CPE)	4114.0	300	13.71	1.71
I_5-(1.0 IW: CPE)	4178.3	300	13.93	1.93

Table 2:Crop water requirement of wheat crop using CROPWAT model

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	2	Init	0.7	1.95	11.7	0	11.7
Nov	3	Init	0.7	1.71	17.1	0	17.1
Dec	1	Deve	0.73	1.84	18.4	0	18.4
Dec	2	Deve	0.85	1.87	18.7	0	18.7
Dec	3	Deve	0.98	1.99	21.9	0	21.9
Jan	1	Mid	1.1	2.24	22.4	0	22.4
Jan	2	Mid	1.12	2.44	24.4	0	24.4
Jan	3	Mid	1.12	2.66	29.3	0	29.3
Feb	1	Mid	1.12	2.87	28.7	0	28.7
Feb	2	Late	1.06	3.11	31.1	0	31.1
Feb	3	Late	0.75	2.41	19.3	0	19.3
Mar	1	Late	0.41	1.41	12.7	0	12.7
					255.7	0	255.7

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STUDY OF PHYSICO-CHEMICAL PARAMETERS AND PLANKTON DIVERSITY OF GARGA RESERVOIR OF BOKARO DISTRICT, JHARKHAND, INDIA

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ABSTRACT

The present study is on **" Physico-chemical parameters and plankton diversity of Garga Reservoir of Bokaro District (Jharkhand)"**. The study was carried on from July' 2012 to June' 2013 at four selected sampling stations.

Monthly variations of Physico-Chemical characteristics of water of Garga were studied and it revealed that the water quality is fairly homogenous and suitable for drinking and pisciculture.

Study of planktons showed 12 species of Phytoplanktons belonging to 7 classes and 11 species of Zooplanktons belonging to 4 different classes.

Key Words: Garga Reservoir, Physico-Chemical Parameters, Planktons.

PAGES: 20 REFERENCES: 5

INTRODUCTION

India is bestowed with plenty of diverse aquatic resources' both natural and man made, supporting huge and diverse bio-diversity, including the fish fauna thereby supporting the livelihood concerns of millions of people.

Among the inland open waters the reservoirs which came into being due to damming of various rivers are unique eco-systems offering tremendous scope for increasing inland fish production.

The state of Jharkhand has an area of 129, 040 sq.km and is drained by many perennial rivers like Koel, Damodar, Brahmani,Kharkhai, Swarnrekha, Ajay etc.

River Garga a hill stream is an important tributary of river Damodar across which the Garga Dam has been constructed at Bokaro (23.29º N 86.09º E).

The secondary data on reservoir fisheries

indicated 141 reservoirs in the state with total expanse at 50313 ha.

Bokaro is an industrial area located in the eastern part of India at 23.29º N 86.09º E.

It is located on the southern bank of river Damodar with Garga, one of its tributaries meandering along the southern and eastern outskirts of the city .On the north the city is flanked by the high range of the parasnath Hills and on the south just beyond the river Garga , it is enveloped by the hillocks.

GARGA RESERVOIR

Location

It is located around 12 km from the city center (23.67ºN 86.10º E) near to railway station on the NH-23. It is a picnic spot for the citizen of Bokaro. The green surroundings and variety of aquatic habitat residing in and around Garga Dam lure school expeditions to the area. The reservoir was constructed in 1973 for the use of the steel plant as well as for a water supply for the people. Now it is also used for fish culture practices by private sector.

Morphometry of The Reservoir

The salient feature of the morphometry of the reservoir is presented in **Table 1**. Basin of the reservoir is concave towards the surface. The shoreline is irregular. Garga reservoir has a maximum area 1474.4 ha and it has maximum depth of 718 feet. The total length of reservoir is 2 km with the widest strength of 1.2 km.

Meteorological Observation

Air Temperature: The minimum air temperature varied from 4 ºC to 28 ºC while the maximum air temperature ranged from 17.6 ºC to 41 ºC.

Rainfall: - Yearly rainfall varied from 80 to 140 cm occurring mostly during June to August.

Hydrological Feature

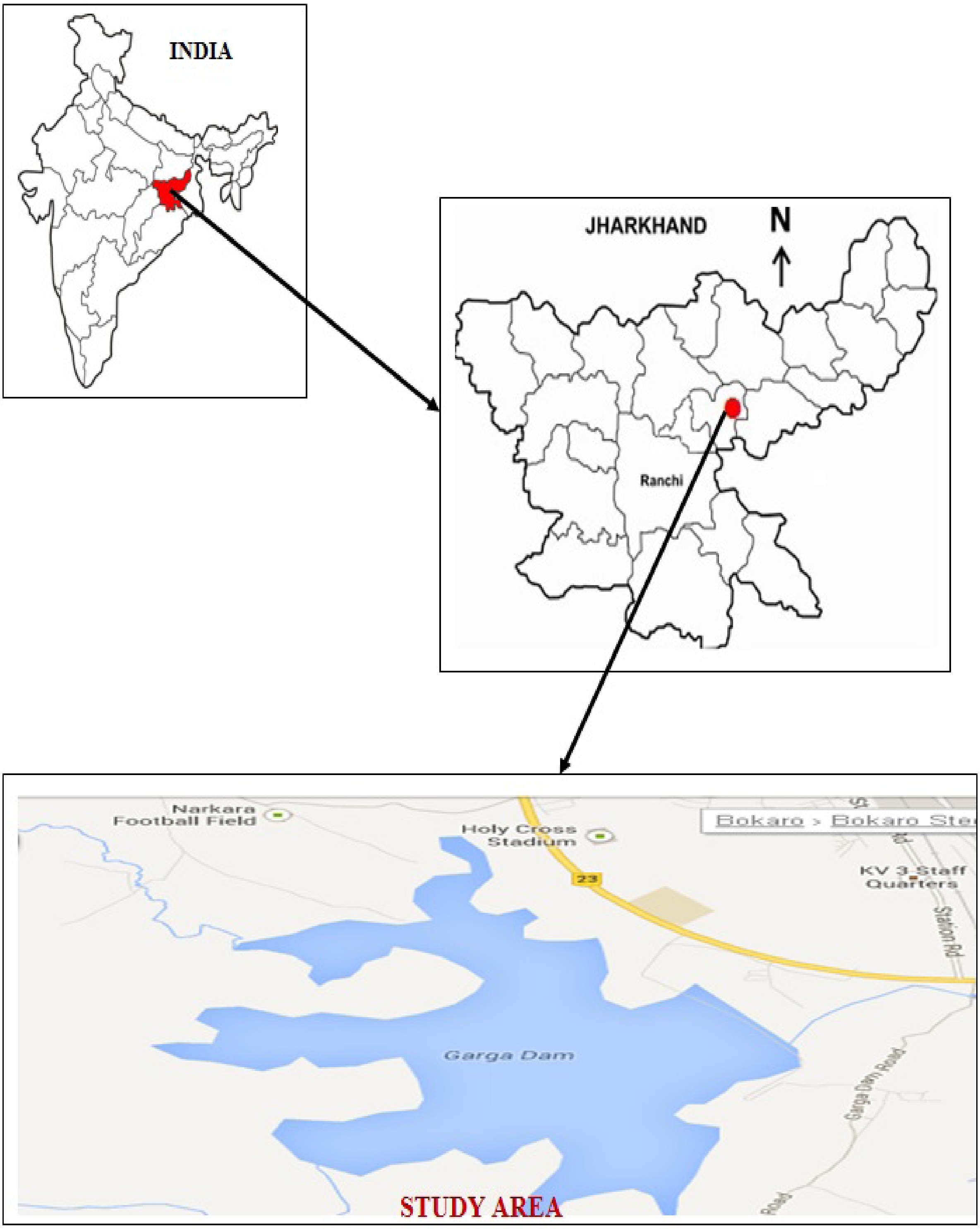
Water Level: - Minimum reservoir level during the period of investigation was 758 feet and the highest level was 770 feet.

Water Inflow and Outflow:- The main inflow into the reservoir is from river Garga throughout the year. The yearly inflow was from 2280 to 4880 million gallon.

Outflow was through the spillways and the power houses. It ranged from 2190 to 4380 million gallon yearly.

Table 1. Salient feature of the morphometry of Garga Reservoir

1). Elevation at top of dam	=	778 feet
2). Maximum reservoir level	=	770 feet
3). Maximum reservoir area	=	1474.4 ha
4). Dead storage area	=	172.24 ha
5). Average area	=	823.32 ha
6). Catchments area	=	1408 ha
7). Gross storage capacity	=	19450947.30 m^3
8). Live storage capacity	=	17177920.20 m^3
9). Maximum reservoir depth	=	718 feet
10). Mean depth	=	352 feet
11). Total inflow	=	2280 to 4880 million gallon.
12). Total outflow	=	2190 to 4380 million gallon.


INDIA
JHARKHAND
N
Ranchi
Narkara
Football Field
Holy Cross
Stadium
Bokaro
KV 3 Staff
Quarters
Station Rd
23
Garga Dam
Garga Dam Road
Road
STUDY AREA

MATERIAL AND METHODS

Study Site: The area selected for the present study is Garga reservoir of Bokaro.it is 12 Km from the City centre (23.67 ºN 86.10 º E) near to the Railway station on the NH 23.

Study Period: The investigation was carried out for a period of 12 month from July' 12 to June' 13.

Physico-Chemical Parameters of Water

Temperature was measured with the help of centigrade thermometer. Transparency was recorded with sacchi disk. pH was determine by using a pH meter. Specific conductivity was estimated by using a conductivity meter.

Standard methodologies of APHA (2005), Jhingran *et. al.,* (1967), Dey and others were followed to measure dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, dissolved phosphate and nitrate.

Samples were collected on monthly basis.

II. Plankton Analysis

In the present study, plankton sampling was taken monthly for one year (July 2012 June 2013) at four different sampling sites (North, South, East and West).

Collection: Plankton net (mesh size 25µm) was swept from 1 to 4m depth and planktons collected were transferred into separate plastic bottle/ containers. 50 lit of water were sieved through plankton net to obtain planktons.

Fixation: Planktons were fixed and preserved in 4 % formalin.

IDENTIFICATION

1ml of the plankton sample was transferred into a Sedgwick rafter plankton counting slide. The chamber was covered and plankton was examined under low power of a microscope.

The number of plankton taxon (N) per liter is given by the equation.

$$N = \frac{A \times C \times 100}{V} = \frac{A \times C \times 1000}{50}$$

A= no. of plankton in 1ml of the sub sample filling the Sedgwick-rafter chamber.

C = ml of the plankton setting volume of plankton.

V = volume of the water sample filtered = 50 litter.

RESULTS AND DISCUSSION

Physico :

Chemical Parameters: The monthly variations of physico- chemical factors of water of Garga Reservoir are presented in **Table-2** and seasonal variations have been represented in table 3. The consideration of the physico – chemical factors in the present study is basic in understanding the

trophic dynamics of water bodies.

Water Temperature: Surface water temperature ranged from 17 ºC to 29 ºC.The temperature raises gradually from early post monsoon to the pre- monsoon month.

Temperature is a physical factor that alters the quality of the water and considered as an important factor in controlling the fluctuation of plankton and functioning of the aquatic ecosystem [1].The surface water temperature confirmed to tropical character and was distinctly influenced by air temperature. Monthly fluctuations in the surface water temperature were correlated to that of ambient temperature.

In the present investigation the season wise analysis showed that the average air and water temperature in reservoir was maximum during summers, comparatively less during monsoon and least during winter season.

Transparency: Transparency ranged from 58.2 cm to 72.3 cm. It was maximum in the month of November, March and April, ensuring a high water column taking part in the primary process.

pH: The pH ranged from 6.8 to 7.8 during the study period. pH dropped to slightly acidic in the month of December 2012, and kept fluctuating irrespective of the months.

The hydrogen ion concentration of natural water is an important environmental factor. The variation in pH is linked with the species composition and life processes of animal and plant communities inhabiting them.

The proper determination of pH may give indirect information about free CO_2 content, alkalinity and dissolved oxygen content. The changes in pH of water will bring about subtle changes in the functional and structural variations in the organisms of the water body.

In the present study, season wise analysis of pH in the reservoir showed maximum value in summer and minimum value in winter. Highest value in summer appeared to be influenced by water level, density of phytoplankton and increased dissolved oxygen.

The pH of Garga reservoir was found to be alkaline throughout study period (July' 12 to June' 13) except in December' 12 and January' 13. The annual fluctuations are small indicating good buffering capacity. High pH in the reservoir may be due to an increased utilization of CO_2 in photosynthesis.

The water having pH range of 6.5 to 9.0 are most suitable for aqua culture. Thus the present water body shows higher pH value and can be used for fresh water fish culture by local fisherman.

Dissolved Oxygen: In the present study DO ranged between 4.4 mg/l and 6.8 mg/l. Maximum DO was observed in the post monsoon months.

Dissolved oxygen in water is of great limnological significance as it regulates many metabolic process of aquatic organisms. Variations in dissolved oxygen in fresh water bodies give a good measure of their trophic state. Oxygen contained is important for direct need of many organisms and affects the solubility of many nutrients and therefore the productivity of aquatic ecosystem.

In present investigation DO concentration in the reservoir exerted a seasonal change. During the winter months higher oxygen concentration in the reservoir indicated higher autotrophic activity and low organic and inorganic load during 2012 -13.The decrease in the amount of DO in summer may be attributed to high temperature due to which the oxygen holding capacity of water decreases.

Free Carbon Dioxide: CO_2 content ranged from 2.5 mg/l to 12.3 mg/l. It was minimum in the post monsoon month and maximum in May.

The CO_2 was present in the water of the Garga reservoir throughout the period of study. The fluctuation in CO_2 values correspond directly with standing crop of phytoplankton. Free carbon dioxide was found to be least in winter months (Nov' 12 to Feb' 13) due to greater utilization of it for photosynthetic activity by the phytoplankton.

In some reservoir absence of free carbon dioxide has also been reported which is apparently due to higher photosynthetic activity and higher pH resulting in the conversion of carbon dioxide into bicarbonate (HCO_3) and carbonate (CO_3).

Total Alkalinity: It was noted between 105 mg/l to 135 mg/l. The main sources of natural alkalinity are rocks containing carbonate, bicarbonate and hydroxide compounds that are abundantly present.

Total alkalinity is used as a measure of productivity. Natural water bodies in tropics usually shows a wide range of fluctuations in total alkalinity values depending upon the location and season.

Water having total alkalinity from 1 to 15 mg/l considered as nutrient poor, 16 to 60 mg/l as moderately rich, and more then 60 mg/l as nutrient rich. Evidently Garga reservoir water in the present study may be categorized as nutrient rich. Total alkalinity in the Garga reservoir remained always high indicating high photosynthetic rate.

In the present study the lower alkalinity values were recorded during monsoon (111.75 mg/l) which may be due dilution effect. Maximum value was in summer which may be attributed to increased rate of decomposition, during which CO_3 librated which reacts with water to form HCO_3.

Total Hardness: Total hardness refers to the concentration of calcium and magnesium. It ranged between 38.7 mg/l to 78.7 mg/l. This indicates that water is soft.

The hardness of water is mainly due to the presence of various salts of Ca and Mg and it is used to classify waters as hard or soft. Degrees of hardness are as follows:-

0 – 75 mg/l = Soft
75 – 150mg/l = Moderately hard
150 – 300 mg/l = Hard
Above 300 mg/l = Very hard

In the present investigation the total hardness varied from 38.7 mg/l to 78.7 mg/l which indicated that water is soft and is suitable for drinking and irrigation purpose after the treatment.

Higher values of total hardness during summer season of present reservoir water can be attributed to decrease in water volume and increase in the rate of evaporation at high temperature.

Phosphate: In the present study phosphate level varied from 0.18mg/l to 0.81 mg/l. In monsoon months nutrients are brought in by the rain water from the surrounding area.

The phosphate is one of the most important major nutrients that is required to biota. The living organisms carry out various vital activities in the presence of this element for the synthesis of nucleic acid and release of energy in the form of ATP. Hence it has been regarded as a limiting factor.

In the present study, PO_4 content in the Garga reservoir fluctuated between 0.18 mg/l to 0.81 mg/l. Highest seasonal mean values were reported during monsoon and lowest during winter. High phosphate during monsoon might be due to influx of rain water containing fertilizer from fields which bring phosphate from catchments area.

Nitrate: The nitrate content in the reservoir ranged from 9.8 mg /l to 16.7 mg /l. highest values of nitrates were recorded in summer.

Nitrate is normally the most common form of combined inorganic and organic nitrogen in lakes and streams. It moves freely through soil along with subsurface water. The concentration and rate of supply of nitrate is intimately connected with the pond use practices of surrounding. It is also a good indicator of contamination from natural and human activities. Levels above 45 mg /l are considered harmful to aquatic organisms.

Nitrates were reported in lower quantities in Garga reservoir which might be due to utilization by phytoplankton and macrophytes. Nitrate was found in better quantity during monsoon and post monsoon.

Specific Conductance: The electrical conductivity value ranged between 209 µmhos/cm and 252 µmhos/cm. The EC values showed marked seasonal variation being maximum during summer and minimum during winter season.

It depends on the nature and concentration of ionized salts. The more conductivity of water the lesser is its resistance to electric flow, there by indicating higher concentration of dissolved salts and higher trophic status of the system. Electric conductivity is used as an index to select the suitability of water for agricultural purpose.

Irrigation water according to the electrical conductivity is classified as E.C < 250 excellent, 250 to 750 Good, 750 to 2000 permissible, 2000 to 3000 doubtful, >3000 Unsuitable. Following this criteria the water of Garga Reservoir is good for irrigation purpose.

The relation of E. C with temperature could be explained on the basis of the fact that solubility of mineral and other inorganic matter increase with increase in water temperature. Moreover the accumulation of dissolved salt due to high rate of evaporation in summer increases the electrical conductivity of water. Hence the present water body shows high electrical conductivity value during summer and low in winter months.

Table – 2 Monthly variations of occurrence of Physio-Chemical Characteristic in Garga Reservoir (Unit/ml) ± SD of Four Observations.

PARAMETER	July '12	Aug '12	Sep '12	Oct '12	Nov '12	Dec '12	Jan '13	Feb '13	Mar'13	Apr '13	May'13	June'13
Temperature (^0C)	24 ± 0.82	24 ± 1.83	23 ± 0.82	21 ± 1.83	19 ± 0.82	17 ± 0.82	18 ± 2.94	20 ± 3.16	22 ± 1.63	25 ± 3.56	29 ± 2.94	28 ± 4.4
Transparency (cm)	58.2 ± 2.65	60.4 ± 3.23	65.2 ± 3.46	66.3 ± 3.85	72.4 ± 2.78	68.4 ± 3.71	67.3 ± 2.26	68.7 ± 3.45	72.3 ± 3.35	71.9 ± 3.87	66.3 ± 2.98	66.7 ± 3.56
pH	7.5 ± 1.29	7.4 ± 0.61	7.4 ± 0.87	7.3 ± 0.54	7.3 ± 0.87	6.8 ± 0.47	6.9 ± 0.94	7.3 ± 0.98	7.3 ± 0.87	7.4 ± 0.95	7.8 ± 0.94	7.7 ± 0.58
DO (mg/l)	5.9 ± 0.54	5.8 ± 0.54	5.7 ± 0.58	6.1 ± 0.08	6.3 ± 0.27	6.8 ± 0.25	6.5 ± 0.32	6.2 ± 0.39	6.0 ± 0.82	5.8 ± 0.18	4.4 ± 0.48	4.8 ± 0.55
Free CO_2(mg/l)	7.2 ± 0.35	7.1 ± 0.18	5.8 ± 0.32	4.5 ± 0.29	4.1 ± 0.25	2.5 ± 0.45	3.9 ± 0.45	4.2 ± 0.29	5.5 ± 0.29	8.8 ± 0.22	12.3 ± 0.29	11.2 ± 0.24
Total Alkalinity (mg/l)	118 ± 3.56	105 ± 2.58	110 ± 3.16	119 ± 2.44	120 ± 2.7	121 ± 2.44	126 ± 2.16	127 ± 2.94	128 ± 2.58	130 ± 4.24	135 ± 2.94	132 ± 2.94
Total Hardness (mg/l)	68.3 ± 5.99	67.2 ± 8.15	65.7 ± 3.64	54.3 ± 10.02	46.7 ± 7.69	38.7 ± 8.74	42.6 ± 8.01	48.9 ± 5.3	56.4 ± 7.5	68.9 ± 11.83	78.7 ± 6.26	74.2 ± 4.38
PO_4(mg/l)	0.42 ± 0.029	0.61 ± 0.025	0.81 ± 0.029	0.73 ± 0.036	0.28 ± 0.036	0.18 ± 0.04	0.25 ± 0.042	0.33 ± 0.018	0.58 ± 0.033	0.56 ± 0.039	0.49 ± 0.036	0.38 ± 0.032
NO_3(mg/l)	13.9 ± 0.37	13.8 ± 0.25	12.9 ± 0.39	12.1 ± 0.49	12.6 ± 0.32	14.4 ± 0.42	16.7 ± 0.59	16.2 ± 0.58	10.8 ± 0.36	9.8 ± 0.52	10.2 ± 0.32	11.8 ± 0.54
Specific conductance (µmhos/cm)	231 ± 11.11	230 ± 12.73	229 ± 16.33	222 ± 8.12	214 ± 6.06	209 ± 19.94	212 ± 17.17	218 ± 15.98	224 ± 14.33	231 ± 9.83	252 ± 22.01	243 ± 11.22

Table – 3 Seasonal variations in physico –chemical parameters of water of Garga Reservoir from July 2012 to June 2013.

Season Parameters	Summer (March'13 – June'13)	Monsoon (July'12 – Oct'12)	Winter (Nov.'12 – Feb'13)
Temperature (^{0}C)	26	23	18.5
Transparency (cm)	69.3 ± 3.24	62.53 ± 3.86	69.2 ± 2.22
pH	7.55 ± 0.23	7.4 ± 0.08	7.08 ± 0.26
DO (mg/l)	5.25 ± 0.77	5.88 ± 0.17	6.45 ± 0.26
Free CO_2(mg/l)	9.45 ± 3.01	6.15 ± 1.27	3. 68 ± 0.79
Total Alkalinity (mg/l)	128.75 ± 6.5	124.25 ± 7.04	113.5 ± 8.89
Total Hardness (mg/l)	69.55 ± 9.64	63.88 ± 6.47	44.23 ± 4.51
PO_4(mg/l)	0.5 ± + 0.09	0.64 ± 0.17	0.26 ± 0.06
NO_3(mg/l)	10.65 ± 0.87	13.18 ± 0.85	14.98 ± 1.87
Specific conductance (µmhos/cm)	237.5 ± 12.45	228 ± 4.58	213.25 ± 3.77

Planktons: Planktons were collected monthly from July' 12 to June' 13 and phytoplanktons and zooplanktons were identified.

Phytoplankton: The monthly variations in the occurrence of phytoplankton in Garga Reservoir have been noticed and presented in the **Table 4.**

Totally 12 different species of phytoplankton belonging to 7 different classes were noticed.

Cyanophycea: It was represented by two genera namely Anabaena and Spirulina. They were observed only in December and January.

Chlorophycea: In it 4 genera were observed namely Oedogonium sp., Spirogyra sp., Volvox sp. and Ulothrix sp. Oedogonium appeared irregularly throughout the study period. Sprirogyra sp.was found from December' 12 to June '13. Volvox was seen only in December' 12 and January' 13. Ulothrix was observed from November' 12 to June' 13.

Bacillariophycea: It was represented by two genera namely Nitzschia sp. and Navicula. Nitzschia appeared only in the month of October and November where as Navicula was observed in December and January.

Charaphycea: It was represented by 1 genus namely Chara. It was observed from December' 12 to June' 13. it was more numerous from April to June.

Rhodophycea: Only one genus Batrachospermum was observed from February to June. It was numerous in June' 13.

Dinoflagellates: Ceratium represented this class and was maximum in September. It was not observed in November, December, January and March.

Euglenoides: Euglena was observed throughout the year except September, November and December.

Maximum number of phytoplanktons was found in May and June.

Table – 4 Monthly variations of occurrence of Phytoplankton in Garga Reservoir (Unit/ml) ± SD of Four Observations.

PHYTOPLANKTON	July '12	Aug '12	Sep '12	Oct '12	Nov '12	Dec '12	Jan '13	Feb '13	Mar '13	Apr '13	May '13	June '13
CYANOPHYCEA												
Anabaena						2 ± 0.82	3 ± 1.41					
Spirulina						5 ± 1.83	5 ± 1.41					
CHLOROPHYCEA												
Oedogonium	1 ± 0.82	1 ± 0.82	2 ± 0.82		2 ± 1.15		2 ± 1.41		1 ± 0		1 ± 1.63	1 ± 0.82
Spirogyra						2 ± 0.82	2 ± 1.41	3 ± 1.41	5 ± 2.94	7 ± 1.63	7 ± 2.92	6 ± 1.83
Volvox						3 ± 1.41	3 ± 1.41					
Ulothrix					2 ± 0.82	1 ± 1.41	3 ± 1.41	2 ± 1.15	3 ± 0.82	5 ± 1.41	5 ± 2.94	6 ± 3.67
BACILLARIOPHYCEA												
Nitzschia				2 ± 0.82	1 ± 0.82							
Navicula						1 ± 0	1 ± 1.15					
CHARAPHYCEA												
Chara						1 ± 1.41	2 ± 0.82	2 ± 1.63	3 ± 1.41	4 ± 2.16	4 ± 0.82	5 ± 1.41
RHODOPHYCEA												
Batrachospermum								1 ± 0.82	2 ± 0.82	2 ± 1.15	3 ± 1.63	5 ± 2.16
DIANOFLAGELLATES												
Ceratium	2 ± 0.82	4 ± 0.82	5 ± 3.56	3 ± 1.41				1 ± 0.82		1 ± 1.41	1 ± 0.82	2 ± 0.82
EUGLENOIDS												
Euglena	1 ± 1.41	2 ± 0.82		2 ± 0.82			1 ± 0.82	1 ± 0	2 ± 1.15	3 ± 1.41	2 ± 0.82	1 ± 0.82
Total No. of Individuals	4	7	7	7	5	15	22	10	16	22	23	26
Total No. of Species	3	3	2	3	3	7	9	6	6	6	7	7

Percentage Composition

Percentage composition of various classes of phytoplanktons is represented in **Table 5.** It revealed maximum percentage of Chlorophycea (46.34%) and minimum percentage of Rhodophycea (7.93%).

Table – 5 Percentage composition of various classes of Phytoplankton of Garga Reservoir, Bokaro

Month	Cyanophycea	Chlorophycea	Bacillariophycea	Charaphycea	Rhodophycea	Dianoflagellates	Euglenoids	Total
July '12		1				2	1	4
Aug '12		1				4	2	7
Sep' 12		2				5		7
Oct' 12			2			3	2	7
Nov '12		4	1					5
Dec '12	7	6	1	1				15
Jan' 13	8	10	1	2			1	22
Feb '13		5		2	1	1	1	10
Mar '13		9		3	2		2	16
Apr' 13		12		4	2	1	3	22
May '13		13		4	3	1	2	23
Jun '13		13		5	5	2	1	26
Total	15	76	5	21	13	19	15	164
%	9.15%	46.34%	3.05%	12.8%	7.93%	11.59%	9.15%	

Diversity Indices of Phytoplankton

Phytoplankton community characteristics such as species richness, evenness and diversity where calculated in the Garga reservoir during July' 12 to June' 13 and presented in the **Table 6**.

The Margalef index (R1) of phytoplankton was minimum (0.514) during September'12 and maximum (1.737) during February'13. The Menhinick index (R2) was maximum (1.581) during February' 13 and minimum (0.756) during August and September' 12.

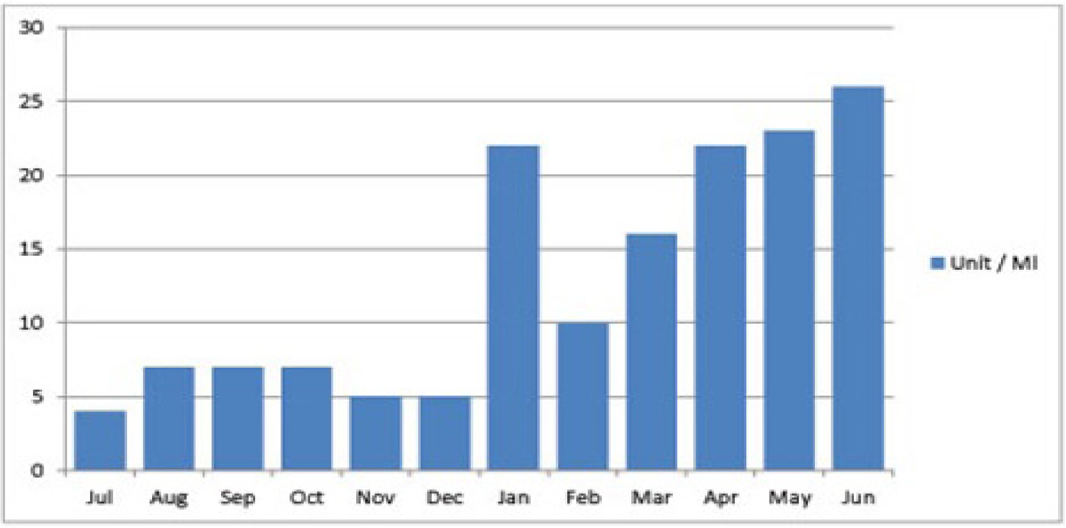
Evenness indices E1, E2, E3, E4, and E5 refer to how the species abundances are distributed among the species. The Alatalo evenness (E5) is preferred over others. It was maximum (2.81) during July' 12 and minimum (0.339) during May' 13.

The Simpson's Index (n) for the phytoplankton community was ranging from 0.167 in July ' 12 to 0.6 in November'12. The Shannon index (H') of phytoplankton was low during the month of November' 12 (0.501) and high during the month of February' 13(1.36). While the values of Hill's first diversity (N1) ranged between 1.651 in November' 12 and 3.899 in February'13. The Hill's second diversity (N2) ranged from 1.667 in November'12 to 5.988 in July' 12.

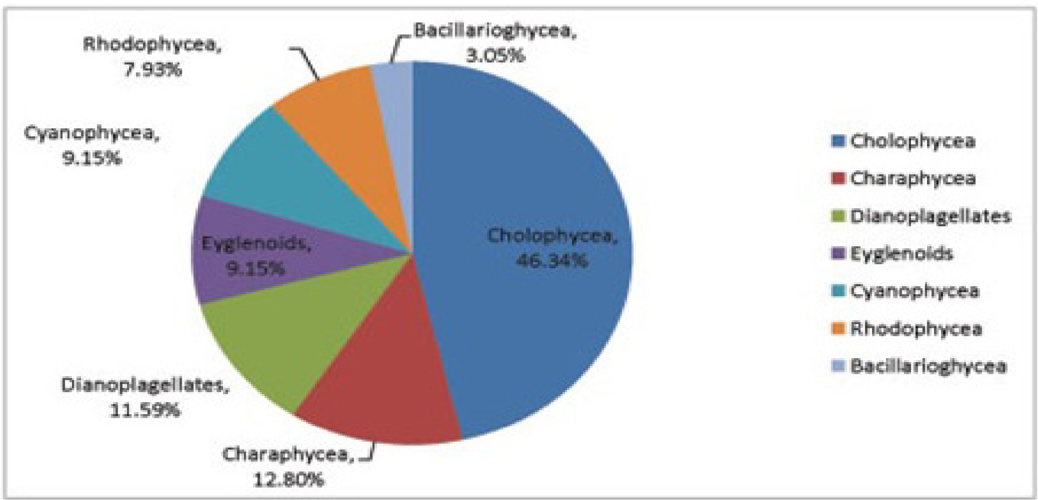
Table – 6 Monthly variations of the various diversity indices for the Phytoplanktons observed in Garga Reservoir, Bokaro (Jharkhand)

Indices		July'12	Aug'12	Sep'12	Oct'12	Nov'12	Dec'12	Jan'13	Feb'13	Mar'13	Apr'13	May'13	June'13
Richness	No	3	3	2	3	2	4	5	5	4	5	5	5
	R1	1.443	1.028	0.514	1.028	0.621	1.108	1.294	1.737	1.082	1.294	1.276	1.228
	R2	1.5	0.756	0.756	1.134	0.894	1.033	1.066	1.581	1	1.066	1.043	0.981
Evenness	E1	0.929	0.816	0.863	0.983	0.723	0.783	0.762	0.845	0.836	0.79	0.771	0.81
	E2	0.925	0.817	0.909	0.981	0.826	0.74	0.682	0.78	0.797	0.713	0.692	0.737
	E3	0.888	0.726	0.819	0.972	0.651	0.654	0.603	0.725	0.729	0.642	0.615	0.671
	E4	2.158	1.224	1.05	1.427	1.01	0.958	0.916	1.049	1.141	0.852	0.53	0.891
	E5	2.81	1.378	1.111	1.646	1.025	0.937	0.88	1.066	1.206	0.794	0.339	0.851
Diversity	λ	0.167	0.333	0.524	0.238	0.6	0.352	0.32	0.244	0.275	0.329	0.545	0.305
	H'	1.02	0.896	0.598	1.079	0.501	1.085	1.226	1.36	1.158	1.271	1.24	1.303
	N1	2.775	2.451	1.819	2.944	1.651	2.961	3.41	3.899	3.186	3.567	3.458	3.683
	N2	5.988	3	1.91	4.2	1.667	2.838	3.122	4.091	3.636	3.039	1.833	3.283

No	No. of species
R1	Margalef index
R2	Mehnick's index
E1	Pielou evenness
E2	Sheldon evenness
E3	Help evenness
E4	Hill evenness
E5	Alatalo index
λ	Simpson's evenness
H'	Shannon evenness
N1	Hill's first diversity
N2	Hill's second diversity



Monthly Variations of Phytoplanktons



Percentage Composition of Various Classes of Phytoplanktons

Zooplankton

The monthly variations in the occurrence of zooplankton in Graga Reservoir have noticed and presented in the **table 7.**

Totally 11 different species of zooplankton belonging to four different classes were noticed.

Rotifera : 3 genera namely Brachionous, Caudatus, *B.falcatus* and Conochilus arboreus were observed.

B.caudatus was more numerous in June whereas *B.falcatus* and Conochilus arboreus were more in February.

Cladorera: It was represented by 4 genera namely *Ceriodaphnia cornuta, Moina micrura, Moina brachiata* and *Diaphanosoma sarsi.*

Ceriodaphnia cornuta was found more in number during January 2013. it was observed from November' 12 to April' 13. *Moina micrura* was more numerous during December' 12 and January' 13. *Moina brachiata* was seen only in December' 12 and January' 13. Daiphanosoma showed irregular presence throughout the year.

Copepods: This class was represented by 3 genera namely *Cyclops, Nauplius,* and *Heliodiaptomus viduus.* Cyclops sp. was observed from November' 12 to June' 13. It was numerous from April ' 13 to June' 13. Nauplius sp.was observed throughout the year except in November' 12 and June' 13. *Heliodiaptomus viduus* was observed November' 12 and February' 13.

Nauplius was found more in number during February 2013.

Ostracoda : Stenocypris sp. was the only representative genes during the investigation period. It was minimum in October'12 and showed continuous presence from March' 13 to June' 13.

Maximum numbers of zooplanktons were found in January' 13 and February' 13.

Table – 7 Monthly variations of occurrence of Zooplankton in Garga Reservoir (Unit/ml) ± SD of Four Observations.

ZOOPLANKTON	July '12	Aug '12	Sep '12	Oct '12	Nov '12	Dec '12	Jan '13	Feb '13	Mar '13	Apr '13	May '13	June '13
ROTIFERA												
Brachionus caudatus	3 ± 1.41	1 ± 0.82				1 ± 0.82	1 ± 1.41		2 ± 0.82	2 ± 1.41	4 ± 0.82	5 ± 1.83
B. falacatus	2 ± 1.41	3 ± 0.82	4 ± 1.83	6 ± 2.58	2 ± 0.82			5 ± 1.83	4 ± 2.16	2 ± 0.82	2 ± 0.82	1 ± 0.82
Conochilus arboreus								4 ± 2.58	3 ± 0.82	2 ± 0.82	1 ± 0.82	1 ± 1.15
CLADOCERA												
Ceriodaphnia Cornuta					4 ± 1.83	6 ± 2.58	15 ± 5.89	4 ± 1.41	2 ± 1.83	1 ± 0.82		
Moina micrura						6 ± 2.16	4 ± 1.83		1 ± 0.82	1 ± 1.41	2 ± 0.82	3±0.82
Moina brachiata						1 ± 0.82	2 ± 1.41					
Diaphanosoma sarsi					2 ± 1.41			1 ± 0.82	2 ± 1.63	2 ± 0.82	3 ± 1.63	5 ± 1.82
COPEPODS												
Cyclops					1 ± 1.41	1 ± 0.82	1 ± 0	3 ± 1.63	3 ± 1.41	4 ± 0.82	4 ± 1.41	5 ± 1.63
Nauplius	1 ± 0.82	1 ± 1.41	2 ± 1.82	1 ± 1.41		4 ± 2.45	3 ± 1.63	7 ± 2.83	2 ±1.41	1 ± 0.82	1 ± 1.41	
Heliodiaptomus viduus					3 ± 0.82			3 ± 1.41				
OSTRACODA												
Stenocypris				1 ± 0.82					2 ± 1.41	3 ±1.41	3 ± 1.63	4 ± 2.16
Total No. of Individuals	6	5	6	8	12	19	26	27	21	18	20	24
Total No. of Species	3	3	2	3	5	6	6	7	9	9	8	7

Percentage composition

Percentage composition of various classes of zooplanktons is represented in **Table 8**. It revealed maximum percentage of Cladocera (34.89 %) and minimum percentage of Ostracoda (6.77 %).

Table – 8 Percentage composition of various classes of Zooplankton of Garga Reservoir, Bokaro

Month	Rotifera	Cladocera	Copepoda	Ostracoda	Total
July'12	5		1		6
Aug'12	4		1		5
Sep'12	4		2		6
Oct'12	6		1	1	8
Nov'12	2	6	4		12
Dec'12	1	13	5		19
Jan'13	1	21	4		26
Feb'13	9	5	13		27
Mar'13	9	5	5	2	21
Apr'13	6	4	5	3	18
May'13	7	5	5	3	20
Jun'13	7	8	5	4	24
Total	61	67	51	13	192
%	31.77%	34.89%	26.56%	6.77%	

Diversity Indices of Zooplankton

Monthly variations in Richness, Evenness and Diversity of zooplankton of Garga reservoir were computed and entered in **Table 9.**

The Margalef index (R1) was maximum in April' 13 (1.038) and minimum in July and September' 12(0.558). The Menhinick index (R2) was low in February' 13 (0.577) and high during October' 12 (1.061).

The Alatalo evenness (E5) of zooplankton was maximum in September' 12 (1.284) and minimum in October' 12 (0.489).

The Simpson's index (n) varied from 0.222 in April' 13 to 0.667 in July' 12. The Shannon index (H') was found to be in the range of 0.451 in July' 12 to 1.355 in April' 13. the values Hill's first diversity (N1) ranged between 1.57 in July' 12 to 3.88 in April' 13. The values of Hill's second diversity (N2) ranged between 1.5 in July' 12 to 4.5 in April' 13.

Among the diversity indices, N1 is measure of abundant species and N2 is measuring of very abundant species.

Table – 9 Monthly variations of the various diversity indices for the Zooplankton observed in Garga Reservoir, Bokaro (Jharkhand)

Indices		July '12	Aug '12	Sep '12	Oct '12	Nov '12	Dec '12	Jan '13	Feb '13	Mar '13	Apr '13	May '13	June '13
Richness	No	2	2	2	3	3	3	3	3	4	4	4	4
	R1	0.558	0.621	0.558	0.962	0.805	0.679	0.614	0.607	0.985	1.038	1.001	0.944
	R2	0.816	0.894	0.816	1.061	0.866	0.688	0.588	0.577	0.873	0.943	0.894	0.816
Evenness	E1	0.651	0.723	0.918	0.671	0.922	0.697	0.534	0.938	0.955	0.978	0.971	0.976
	E2	0.785	0.826	0.945	0.696	0.918	0.717	0.599	0.934	0.94	0.97	0.96	0.967
	E3	0.57	0.651	0.89	0.545	0.877	0.576	0.399	0.902	0.919	0.96	0.947	0.956
	E4	0.955	1.01	1.134	0.734	1.089	0.903	0.966	1.08	0.98	1.16	1.124	1.098
	E5	0.877	1.025	1.284	0.489	1.141	0.819	0.923	1.124	0.973	1.215	1.168	1.132
Diversity	λ	0.667	0.6	0.467	0.652	0.333	0.515	0.576	0.33	0.271	0.222	0.232	0.236
	H'	0.451	0.501	0.636	0.736	1.012	0.766	0.586	1.03	1.323	1.355	1.345	1.352
	N1	1.57	1.651	1.89	2.089	2.753	2.152	1.797	2.803	3.758	3.88	3.841	3.868
	N2	1.5	1.667	2.143	1.533	3	1.943	1.736	3.026	3.684	4.5	4.318	4.246

No	No. of species
R1	Margalef index
R2	Mehnick's index
E1	Pielou evenness
E2	Sheldon evenness
E3	Help evenness
E4	Hill evenness
E5	Alatalo index
λ	Simpson's evenness
H'	Shannon evenness
N1	Hill's first diversity
N2	Hill's second diversity

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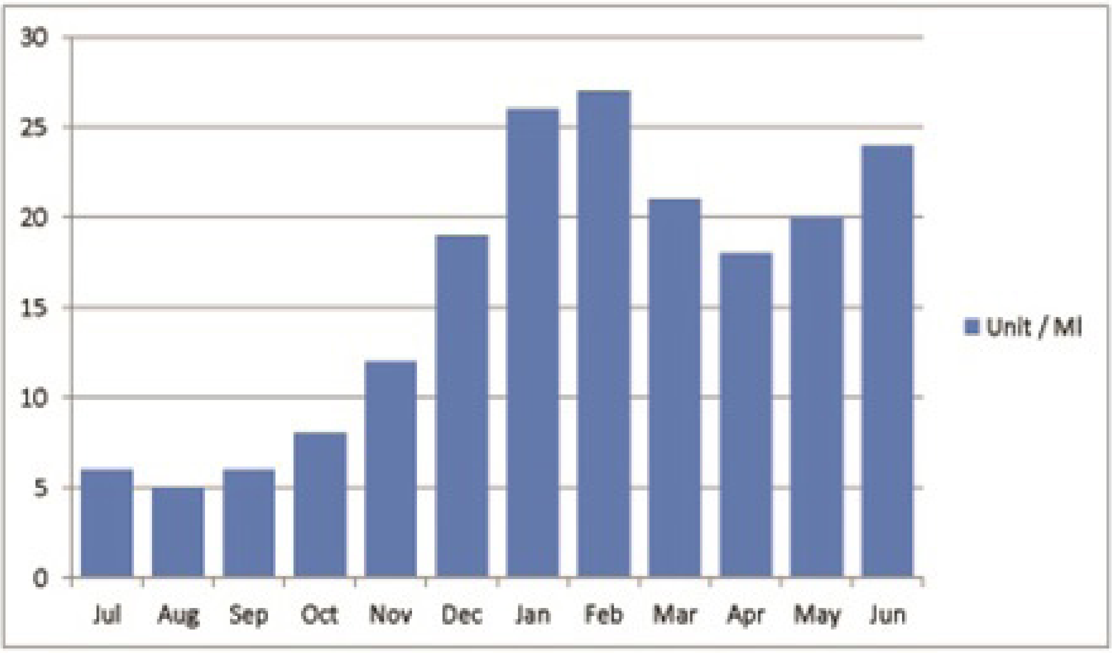

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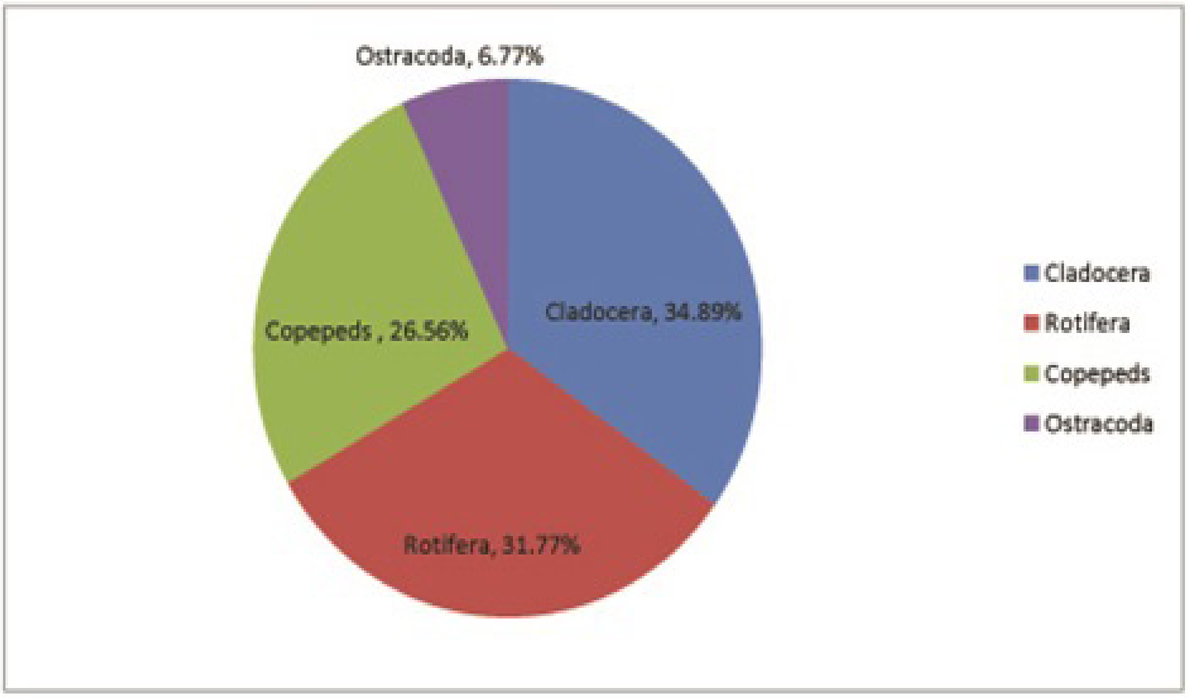

Percent composition of various classes of zooplanktons

CONCLUSION

The result showed that water of Garga reservoir is suitable for drinking, irrigation and fish culture. Plankton study was carried out to understand its relation with water quality parameters and fish production. Among phytoplantons Chlorophycea was more prominent and among zooplanktons Cladocera and Rotifera showed dominance.

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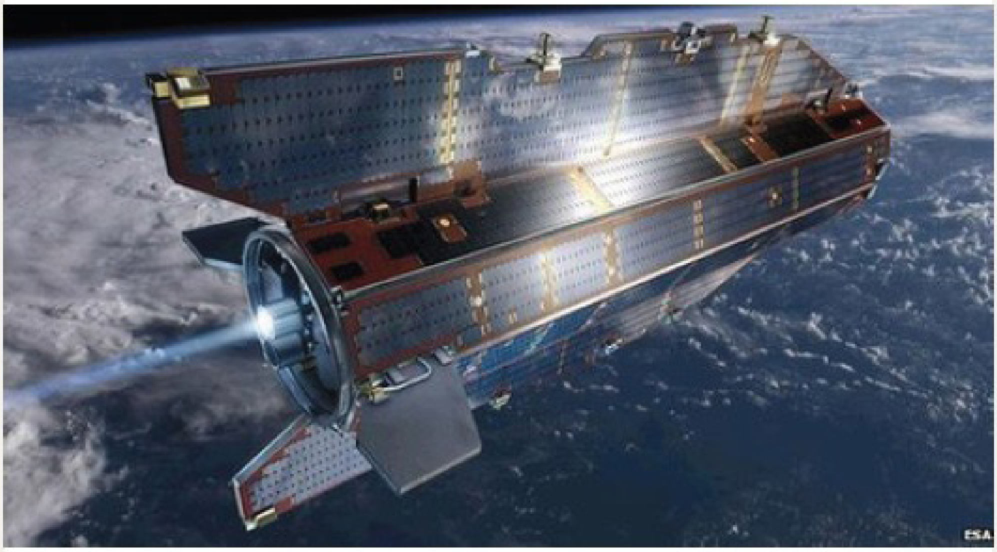

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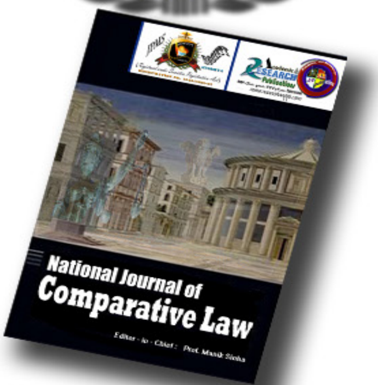

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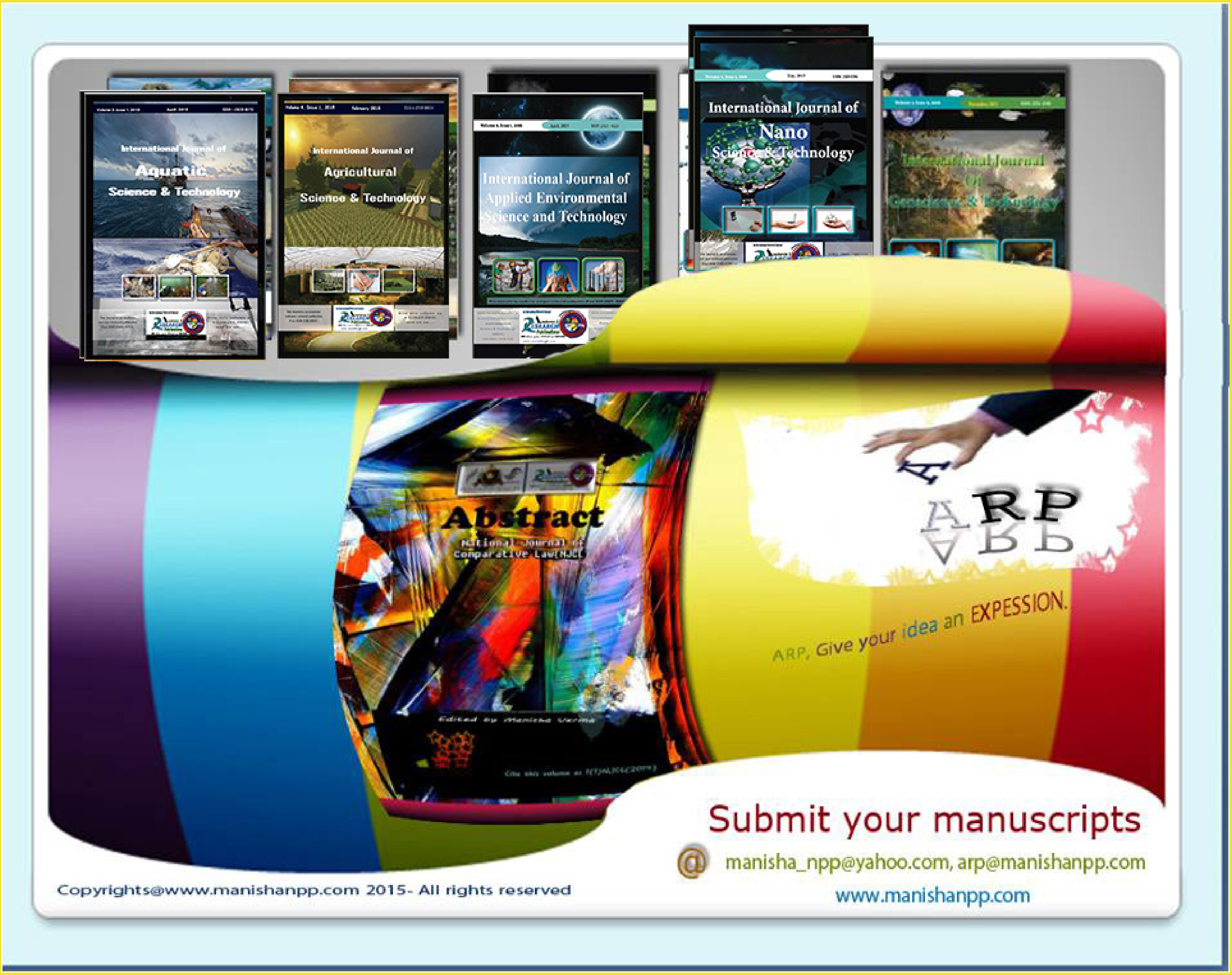

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